2020 / October 17

The 11th Workshop on Meshless Methods and Boundary Element Methods in Taiwan

第十一屆台灣無網格法與邊界元素法學術研討會

會議手冊

主辦單位

國立臺灣海洋大學河海工程學系

協辦單位

國立臺灣海洋大學海洋工程科技中心

國立臺灣海洋大學河海工程學系系友會

科技部工程司工程科技推展中心

台灣工業與應用數學會

力學聲響振動實驗室

序言

台灣無網格法與邊界元素法學術研討會每年定期舉辦，是台灣學術界與產業界的一年一度盛事，提供台灣學術界、產業界與研究單位一個交流與討論的平台，期望能促進台灣有關無網格法與邊界元素法的學術理論研究與工業應用，加強數學研究、工程力學理論與實務應用相結合，提升我國的計算力學與應用數學學術領域研究強度，並加快相關工業應用產品的研發速度。

本屆(第十一屆)台灣無網格法與邊界元素法學術研討會於十月十七日在國立臺灣海洋大學舉辦，本研討會在主辦單位與協辦單位相關同仁的共同努力下，安排了兩場大會演講，分別邀請了國立成功大學胡潛濱講座教授與國立交通大學楊子儀教授，分別針對邊界元素法與無網格法的最新國際發展研究進行討論。相信透過這兩位國際知名學者的演講可以促進國內計算力學與應用數學領域的發展與國際化，也能加強國內對於邊界元素法與無網格法的理論研究與工業應用。此外，本次研討會規劃了兩場迷你論壇，分別針對「邊界元素法」與「無網格法」主題，邀請國內頂尖研究專家與學者，分別針對個人最新研究成果、國際研究趨勢與工業應用方向進行專題報告。本研究會共邀請十三位講者進行學術演講，預估與會貴賓與眷屬約有一百人，使得本屆研討會內容豐富多樣且精采可期。

今年適逢國立臺灣海洋大學河海工程學系六十週年系慶，河海工程學系是一個結合土木、水利與海洋工程領域的系所，在過去一甲子的時光中培育了產、官、學、研各領域的頂尖人才，為臺灣工程建設等相關領域做出重大貢獻。為了慶祝河海工程學系六十週年系慶，規劃本研討會為六十週年系慶系列活動之一，共同慶祝河海工程學系一甲子系慶，感謝過去系上師生對於臺灣各方面的卓越貢獻，也期許河海工程學系在未來的一甲子能持續培育國際化的頂尖工程人才，以及完成國際知名學術研究，成為世界知名頂尖教育與學術研究系所。

今年的台灣無網格法與邊界元素法學術研討會是由國立臺灣海洋大學河海工程學系主辦，並由科技部工程司工程科技推展中心、台灣工業與應用數學會、國立臺灣海洋大學海洋工程科技中心、國立臺灣海洋大學河海工程學系系友會共同協辦。本研討會經由主辦單位與協辦單位、籌備委員會、各主持人與演講者，及工作人員的努力付出，第十一屆台灣無網格法與邊界元素法學術研討會才能順利舉行，在此表達誠摯的感謝。本次研討會在國立臺灣海洋大學基隆校區舉辦，希望各位專家學者在學術討論之餘，也能享受基隆的美景與欣賞東北角海岸獨特的海岸風貌。最後，祝此次大會圓滿成功，各位嘉賓與工作同仁身體健康，萬事如意。

第十一屆台灣無網格法與邊界元素法學術研討會主席
國立臺灣海洋大學河海工程學系
郭世榮 教授兼系主任

第十一屆台灣無網格法與邊界元素法學術研討會總幹事
國立臺灣海洋大學河海工程學系
范佳銘 特聘教授
中華民國 109 年 10 月 10 日

回顧以往，邁向未來

邊界元素法(Boundary Element Method, BEM)於 1970 年代發展至今已有逾 40 年歷史，其主要的理論基礎則是由格林恆等式出發所導得的積分方程。而這個名詞最早是在 1977 年由 Brebbia 與 Dominguez 發表於 Applied Mathematical Modelling (Volume 1, page 372)首先提到。其主要精神則是本著問題的邊界作離散所發展出來的一套數值方法。在國際學術舞台上，邊界元素法一直有許多學者從事這方面的研究，亦有舉辦許多相關學術研討會，如 Beteq、BETECH、BEM/MRM、IABEM、ICOME、華人工程計算方法學術會議等。此法也被廣泛應用於許多工程問題的分析，如 地下水滲流問題、穩態熱傳導分析、裂縫成長分析與預測、大地應力分析等。國外亦有許多軟體公司將此法發展成套裝軟體，例如: SYSTEM NOISE、BEASY CRACK、BEST3D 等，可見此法之相關研究仍具有高度之經濟價值。

在臺灣有許多大學教授與專家學者都曾經從事過邊界元素法或相關數值方法的研究，會議榮譽副主席陳正宗特聘講座教授在聆聽現任 EABE 期刊主編程宏達教授的演講中得知，任職學校－國立臺灣海洋大學為全球從事邊界元素法研究人力密度最高的學校，有許多教授對邊界元素法這個領域曾經投入研究多年。除海洋大學外，臺灣亦有多位教授從事這領域的相關研究。近二十年來，臺灣曾對邊界元素法開設過短期研討課程。於 1986 年，美國 Kentucky 大學 Rizzo 教授與 Shippy 教授以及 Cornell 大學 Mukherjee 教授，在國科會的資助下，曾應台大應力所鮑亦興院士之邀來台講學，於台大應力所開設為期一週的短期研討課程，參加者背景為土木結構固力師生與工程師。1989 年，台大楊德良教授邀請 Liggett 教授來台訪問，1998 年陳教授邀請程教授來台演講，1998 年國家高速電腦中心，也在國科會的資助下，邀請國內十幾位專家學者，舉辦了一場邊界元素計算研討會。與會者為工學院各系（電機、機械、土木、河工與水利）的教授群，然前述二會並沒有來自數學界的朋友一同參與盛會。在數

學領域上，國內也有許多學者從事邊界積分方程法之相關研究。然而，國內並無相關單位或機構針對此領域舉辦研討會，提供交流平台，讓這些專家學者缺少相互切磋的機會與互相交流的機會及平台。再者，工程領域學者與數學家間的互動，一直有再加強聯繫的空間。如果能有個機會，讓工程師分享其實務應用經驗，而數學家也能提供其研究成果，增進彼此雙方的交流，進一步達成數學與工程的結合，對工程界與學術界而言，都是很有意義的。

因此，於 2010 年時，適逢河工系五十週年系慶，基於國內已十餘年未舉辦過邊界元素法(工程)或積分方程法(數學)相關研討會，且此數值方法乃為本系研究最大之特色。故申請人於 2010 年 10 月五十週年系慶當天，舉辦一場邊界元素法與積分方程及其相關數值方法之研討會，邀請十名國內工程科系與數學系教授進行演講與交流，重燃大家對邊界元素法研究的熱情。此外，亦有三、四十位國內邊界元素法專家學者前來參與此次盛會。對本人而言，看到此景著實是個鼓勵，也興起在國內每年舉辦邊界元素法相關會議的想法。在諸位學術同好的相挺下，一年後於成大八十週年校慶，由成大數學系李國明教授接辦第二屆，第三屆則於 2012 年移師至逢甲大學，由航太系夏育群教授主辦，第四屆會議則是在 2013 年 3 月，由中興大學壽克堅主任主辦，此次會議更邀請美國國家工程院 Crouch 院士來台與會交流並進行學術訪問，讓此會議日漸國際化與規模，第五屆則是移師到南台灣，由中山大學應用數學系呂宗澤主任籌畫。2015 年第六屆邊界元素法研討會，則擴大與第四屆兩岸地震工程青年學者研討會一同於國家地震工程研究中心舉行，提升至兩岸學者交流。2016 年則由 NCTS(National Center for Theoretical Sciences)李志豪教授主辦，結合台日反算問題研討會，讓此會議更趨國際化。2017 年則由宜蘭大學陳桂鴻教授與吳清森教授承辦；2018 年與 2019 年則移師到南台灣，分別由義大財務與計算數學系黃宏財主任與成大工科劉立偉教授主辦。今年正逢海大河工系一甲子，再度回到海大舉辦。研究需要累積，而學術則需要傳承，此次接棒給年輕一輩，由范佳銘特聘教授與李應德教授主辦，而陳正宗特聘講座教授則擔任會議榮譽副主席。此次會議除了邊界元素法之外，亦有無網格法計算領域的同好加入，會

議更加豐富，希冀會議能綿延流長，各位計算力學之同好能夠透過此會議平台充分交流，累積台灣計算力學之能量。

會議榮譽副主席 陳正宗 特聘講座教授

於海大河工二館 306 Oct. 8, 2020

History & Background Taiwan BEM workshop (1986-2020) see you in NTOU (BEM 11)

History & Background Taiwan BEM workshop (1986-2020) see you in NTOU (BEM 11)

Year	Host	Organizer	Ceremony	Plenary lecturer
1986	NTU IAM	Prof. Y H Pao	Establishment of NTU IAM	Prof. F J Rizzo
1989	NTU	Prof. J. A. Liggett	NSC	Prof. D L Young
1998	NSC	Prof. J T Chen	NCHC	Prof. A H D Cheng
2010	NTOU-HRE-MSV	Prof. J T Chen	NTOU-HRE 50th anniversary	Prof. Z C Li
2011	NCTS(South)	Prof. K M Lee	NCKU 80th anniversary	NCKU
2012	Feng Chia University	Prof. Y C Shiah	Prof. Hong's 60th birthday	Prof. H-K Hong
2013	National Chung Hsing University	Prof. K J Shou	Congratulations for Academicain	Dean S L Crouch Academician,NAE
2014	National SYS University	Prof. T T Lu	Prof. Young's 70th birthday	Prof. D L Young
2015	NCREE (cross strait)	Dr. R Z Wang	NCREE	Cross strait ceremony
2016	NCTS (Japan-Taiwan)	Prof. J H Lee	NCTS	Prof. H-K Hong Prof. W-W Lin
2017	NIU	Prof. I L Chern Prof. K H Chen	Ilan Univ	Prof. H-K Hong Prof. W-C Wang
2018	ISU	Prof. H T Huang Prof. I L Chen	Iso univ.	Prof. D L Young
2019	NCKU	Prof. L W Liu	Cheng Kung Univ	Prof. J T Chen
2020	NTOU	Prof. Y T Lee Prof. C M Fan	NTOU-HRE 60th anniversary	Prof. C B Hwu


Taiwan BEM/Meshless Meeting (2010-2019)

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許泰文講座教授兼校長 國立臺灣海洋大學

會議榮譽副主席：

陳正宗特聘講座教授 國立臺灣海洋大學河海工程學系

會議主席：

郭世榮教授兼系主任 國立臺灣海洋大學河海工程學系

研討會總幹事：

范佳銘特聘教授 國立臺灣海洋大學河海工程學系

工作委員會：

石瑞祥副教授 國立臺灣海洋大學河海工程學系

李應德助理教授 國立臺灣海洋大學河海工程學系

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高聖凱助理 國立臺灣海洋大學河海工程學系

朱瓊琳同學 國立臺灣海洋大學河海工程學系

會議議程

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13:50</td><td>講題：邊界元素法求解選擇權價格問題
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國立成功大學數學系</td></tr>
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14:10</td><td>講題：A Multipole Accelerated Method for Regularized Boundary Integral Equations
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國立成功大學航空太空學系</td></tr>
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國立成功大學工程科學系</td></tr>
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大會邀請演講I：講者簡介

日期：10 月 17 日 10:00-11:00，地點：工學院一樓視聽室

Prof. Chyanbin Hwu

Institute of Aeronautics and Astronautics
National Cheng Kung University, Tainan, Taiwan

Chyanbin Hwu obtained his B.S. degree of Civil Engineering from National Taiwan University in 1981, M.S. degree of Power Mechanical Engineering from National Tsing-Hua University in 1985, and Ph.D. degree of engineering mechanics from University of Illinois at Chicago in 1988. He joined Department of Aeronautics and Astronautics, National Cheng Kung University, Taiwan, as an associate professor in 1988, became a full professor in 1992 and a distinguished professor in 2003, and a chair professor since 2008. He was elected to be the president of the Society of Theoretical and Applied Mechanics (R.O.C.) in 2008. He is a fellow of the Aeronautical and Astronautical Society (R.O.C.), and the Society of Theoretical and Applied Mechanics (R.O.C.) starting from 2006. He was the recipient of academic award (Ministry of Education, R.O.C.) in 2014, Sun Fang-Duo medal in 2011, outstanding research awards (National Science Council, R.O.C.) in 1995-1996, 1998-1999, 2002-2004, and became the outstanding distinguished research fellow (National Science Council, R.O.C.) in 2005-2012. He served as member of editorial board for International Journal of Solids and Structures in 2000-2005, editorial advisor for Journal of Mechanics of Materials and Structures in 2005-2015, and associated editor for Transactions of JSASS (The Japan Society for Aeronautical and Space Sciences) in 2014-present. His current research interests include mechanics of composite materials, fracture mechanics, anisotropic elasticity, and nanomaterials.

大會邀請演講I

A Unified Formalism for Boundary Element Analysis of Anisotropic Materials

Chyanbin Hwu

Institute of Aeronautics and Astronautics, National Cheng Kung University, Tainan, Taiwan, R.O.C.

Abstract

Stroh's formalism provides a unified mathematical expression for different kinds of problems and materials. This unified feature really benefits the development of boundary element method (BEM), because slightly changes of computer codes will make it suitable for various kinds of problems and materials. The BEM developed by this way can easily cover the elastic analysis of two-dimensional (includes plane strain, generalized plane strain, and generalized plane stress), plate bending, coupled stretching-bending, and three-dimensional deformations. It can also be extended to the piezoelectric, piezomagnetic, magnetic-electro-elastic, viscoelastic materials, and the ones under thermal environment. If a special fundamental solution is embedded in the associated boundary integral equations, the meshes along the special portion of BEM can be exempted, which will increase the accuracy and efficiency of computation. Currently, the available special fundamental solutions include the ones for infinite space, half space, interfaces, holes, cracks, and inclusions. Combining the use of special fundamental solutions and our recently developed boundary-based finite element method, the problems with multiple holes, cracks and inclusions can then be solved in an efficient and accurate way. Based upon the above concept, the BEM is also further developed for the dynamic analysis and contact analysis by using only static fundamental solutions. Thus, a simple "unified" really achieves a "broaden" task by BEM.

大會邀請演講II：講者簡介

日期：10 月 17 日 11:00-12:00，地點：工學院一樓視聽室

楊子儀(Judy P. Yang) 教授

Department of Civil Engineering
National Chiao Tung University (NCTU), Hsinchu, Taiwan
Email: jpyang@nctu.edu.tw

Education:

PhD, Department of Civil and Environmental Engineering,
University of California, Los Angeles (UCLA)
MS, Department of Civil Engineering, National Taiwan University, Taipei, Taiwan
BS, Department of Civil Engineering, National Taiwan University, Taipei, Taiwan

Experiences:

2019/8-present: Professor, Civil Engineering Department, NCTU, Taiwan
2016/8-2019/7: Associate Professor, Civil Engineering Department, NCTU, Taiwan
2012/8-2016/7: Assistant Professor, Civil Engineering Department, NCTU, Taiwan

Honors/Awards:

1. 亞太地區計算力學學會 2019 APACM 優秀青年學者獎
2. 國際華人計算力學學會 2018 ICACM 優秀青年學者獎
3. 中華民國結構工程學會 2018(107 年度)優秀青年結構工程教授獎
4. 2019 ESI Highly Cited Paper and Research Front: State-of-the-Art Review on Modal Identification and Damage Detection of Bridges by Moving Test Vehicles.
5. 2018 ESI Highly Cited Paper: State-of-the-Art Review on Modal Identification and Damage Detection of Bridges by Moving Test Vehicles.
6. Outstanding Reviewer of Heliyon in 2017
7. 國立交通大學 2017 土木系傑出教學獎
8. 國立交通大學 2016 學年度績優導師獎
9. 國立交通大學 2015 學年度績優導師獎

10. 國立交通大學 2014 學年度績優導師獎
11. 國立交通大學 2013 學年度績優導師獎
12. Travel Award in 2011 US National Congress on Computational Mechanics
13. International Scientific Advisory Committee of ICCM 2019 (International Conference on Computational Methods)
14. International Committee of ICCADP 2018 (International Conference on Civil, Architecture & Disaster Prevention)
15. International Scientific Committee of ISBDAS 2018 (International Symposium on Big Data and Applied Statistics)
16. Reviewer Committee of ISEV 2018 (8th International Symposium on Environmental Vibration and Transportation Geodynamics)
17. Scientific Committee of EASEC-15 (East Asia-Pacific Conference on Structural Engineering and Construction)
18. International Scientific Advisory Committee of ICCM 2017 (International Conference on Computational Methods)
19. International Scientific Committee of IACM (International Association for Computational Mechanics) and APACM (Asian Pacific Association for Computational Mechanics) for WCCM XII and APCOM VI in 2016
20. 中華民國力學學會第 38 屆理事

Research Interests and Publications:

Dr. Yang's research direction includes two topics: strong form meshfree methods for analysis of structural mechanics problems and advanced FEM for analysis of vehicle-bridge interaction and structural dynamics problems. She published one book entitled as "Vehicle Scanning Method for Bridges" in 2019 and one chapter entitled as "Image Based Multiscale Modeling of Porous Bone Materials" in the book "Multiscale Simulations and Mechanics of Biological Materials" in 2013. In addition, Dr. Yang has published 25 SCI papers and 1 EI paper so far. She also serves as reviewers in 21 international journals.

大會邀請演講II

加權再生核函數配置法於邊界值問題分析

楊子儀

國立交通大學土木工程學系

摘要

從工程與科學的角度來看，多數的物理現象皆可透過簡化之數學模型來模擬，亦即只要能以邊界值問題之方式描述，透過求解偏微分方程式，其物理行為皆可透過數值方式做預測。有鑑於此，本次演講將以近年來逐漸發展出之無網格法中之再生核函數配置法為主題，首先介紹再生核形狀函數之起源與發展，接著介紹再生核形狀函數如何從傳統弱形式表述法求解邊界值問題跳脫至強形式表述法求解邊界值問題，最後介紹再生核函數配置法除了求解正算之邊界值問題外，其近年之應用，特別是反算之邊界值問題分析。

一般而言，反算問題因其本身之不適定與不穩定，一直以來，文獻上如何發展一有效、簡單之數值方法以取得具高精度之近似解為一待克服之問題。在本人研究團隊先前之研究中，透過數學上之誤差分析與數值上之收斂研究，證明了加權再生核函數配置法可以有效求解反算柯西問題與反算彈性力學問題，並且具有一定之收斂率，證明使用加權最小二乘泛函所推導之加權離散配置方程式可以有效平衡定義域內與邊界上之誤差，進而提高數值近似之精度，其中加權配置法中之權重作用與正則化法有異曲同工之妙。除了單連通域之反算問題，對於具有複雜幾何之多重連通域之反算問題，亦將透過在邊界條件上施加擾動與使用不規則佈點方式，以證明所提出方法之數值穩定性。

迷你論壇I

日期：10 月 17 日 13:30-15:30，地點：河工二館 307 室

講者	單位	講題
沈士育 教授	國立成功大學 數學系	邊界元素法求解選擇權價格問題
黃維信 教授	國立臺灣大學 工程科學及海洋工程學系	A multipole accelerated method for regularized boundary integral Equations
夏育群 教授	國立成功大學 航空太空學系	3D BEM Analysis of Anisotropic Materials with Thermal Effects of Domain Heat Sources
劉立偉 助理教授	國立成功大學 工程科學系	A $C\ell_3$-valued boundary element method for isotropic-linear elastic materials
劉芷妤 博士後研究員	國立臺灣海洋大學 河海工程學系	Study on Variably Saturated Groundwater Flow Using a Spacetime Collocation Meshless Method
廖駿偉 教授	長庚大學 機械工程學系	BEM + MoM for Analysis of Plasmonic Modes

邊界元素法求解選擇權價格問題

沈士育

國立成功大學數學系

摘要

選擇權(option)甚早期間即已存在，而其定價理論則在 1973 年 Black-Scholes 出版著名論文後，所謂的 Black-Scholes medel 即為普遍接受的之定價方法。在 Black-Scholes 理論中，假設標的物價格為一具有固定飄移率之幾何布朗運動。因此股價之隨機模型只由兩個常數決定，及波動率與飄移率 ，而選擇權價格則為標的物價格與時間的函數，因而存在一投資組合不隨股價短期波動而改變價值(稱無風險投資組合)，而 Black-Scholes 斷言此投資組合之報酬率幣相當於利率(無風險利率)，由此即可導出著名之 Black-Scholes 方程式(PDE)經由變數代換後可轉變成線性均質之熱傳導方成式(Heat Equation)。某些選擇權具有特別的合約使得 PDE 變成邊界質問題，而邊界位置隨時間而變。也就是說這模式得一 Heat Equation 的 moving boundary problem。我們將可以專換公司債為例，藉由邊界元素法求解得選擇權價格。

Keywords: Option Pricing, Black-Scholes Equation, Heat Equation, Moving boundary, Boundary Element Method

A multipole accelerated method for regularized boundary integral Equations

鄭人愷、黃維信

國立臺灣大學工程科學及海洋工程學系

Abstract

The objective of the present project is to solve the Regularized Boundary Integral Equation (BIE) with the Fast Multipole Method (FMM) for the 2-D potential problems. Assume the flow field satisfy the potential theory. Then apply the trapezoidal rule or Gauss-Legendre rule to evaluate the boundary integrals. Finally, apply iterative solvers (e.g., GMRES) to solve the equations. CPU time and the Root-mean-square errors are discussed on different numbers of Taylor series expansion terms and the number of levels in the hierarchical structure of the Fast Multipole Method. Compare the CPU time and the Root-mean-square error in several combinations of the FMM, BIM, and the Boundary Element Method. The results show that FMM-BIM saves over 80% CPU time than FMM-BEM if the required root-mean-square error is less than 10-4.

3D BEM Analysis of Anisotropic Materials with Thermal Effects of Domain Heat Sources

Y. C. Shiah

Department of Aeronautics and Astronautics, National Cheng Kung University, Tainan, Taiwan, R.O.C.

Abstract

In various engineering applications, anisotropic materials have been extensively used for different purposes. Among various engineering problems, anisotropic thermoelasticity is one of the most important issues that have gained attentions from engineers due to its important role played in engineering practice. Due to electrical heating or chemical reactions inside domain, the problem of thermoelasticity involving internal volume heat sources appears to be an important topic worthy of investigation. Although analytical solutions to specific thermoelastic problems with simple geometries and boundary conditions exist, studies of general engineering problems with complicated geometries and boundary conditions still need to rely on numerical tools, for instance the finite element method and the finite difference method.

Being recognized as a powerful alternative numerical tool, the boundary element method (BEM) has been considerably applied in many engineering disciplines owing to its feature that only boundary discretization is needed. This is considered a major advantage especially for modeling three-dimensional problems; however, an additional volume integral shall arise in the boundary integral equation (BIE) for the presence of internal volume heat source and its direct integration will generally require discretization over the entire domain. This domain discretization will certainly destroy the BEM's most advantageous feature of boundary discretization. For avoiding the direct integration, a couple of numerical approaches have been proposed over the years, including the domain fanning approach, the particular integral approach, the dual reciprocity method, the analytical transformation method, the radial integration method, and the Cartesian transformation method. Another scheme to avoid direct evaluation of the domain integration is to treat the problem as a special class of coupled thermoelasticity by use of the fundamental solutions for particular classes of uncoupled cases. For avoiding direct integration of the domain integral, Sladek et al. also presented an iterative approach. Among

these approaches mentioned above, the ATM is perhaps the most mathematically elegant since the additional domain integral is analytically transformed onto the boundary without incurring further approximation. In a similar spirit, the author has also applied the ATM for treating 3D generally anisotropic solids subjected to inertial loads. Although the ATM has been applied to solve both 2D and 3D problems of thermoelasticity for isotropic bodies, its extended treatment to deal with 3D anisotropic cases had not been successfully resolved until the analytical transformation for 3D cases was presented by the author for the case when no heat source was involved. Also, this technique has been applied to the BEM analysis to treat inertial effects in 3D anisotropic elastic bodies. By that approach, evaluation of the extra volume integral was carried out for an equivalent "isotropic" domain, where the corresponding thermal field is governed by the standard Poisson's equation. Under the same work frame, Shiah and Chong have further implemented this approach in the analysis of interior thermoelastic stresses for 3D anisotropic structures. In the approach, the extra volume integral needs to be transformed onto the distorted boundary; its computation appears to be somewhat tedious. For avoiding the mapping process, the author presented a direct transformation approach to analyze thermal stresses in 2D anisotropic materials when no heat source appeared inside. In light of the fact that internal heat sources are pretty common in engineering practice due to, for example, electrical heating or chemical reactions inside domain, the treatment considering the presence of internal volume heat source is sometimes inevitable. For arbitrarily distributed internal heat sources, one may always represent the continuous distribution of heat sources by a quadratic form in terms of coordinates via a statistic analysis of least square. With the thermal pre-process, the present work is to extend the previous treatment considering constant volume heat source such that the extra volume integral arising from internal quadratic volume heat source can be analytically transformed onto boundary. All formulations presented have been successfully implemented in the BEM, programmed by FORTRAN based on quadratic isoparametric elements. For illustrating the successful implementation, a few numerical examples are presented with verifications of FEM analyses in the end.

A $C\ell_3$-valued boundary element method for isotropic-linear elastic materials

Li-Wei Liu

Department of Engineering Science, National Cheng Kung University

Abstract

A $C\ell_3$-valued boundary integral equations (BIEs) for multiple-component spatial harmonic functions have been developed. Besides the $C\ell_3$-valued BIEs whose observation point inside the domain and outside the domain, the BIEs whose observation point on the boundary on the boundary have been derived. Then a $C\ell_3$-valued boundary element method (BEM) can be developed via the discretization of BIEs. Since the oriented surface element is used, the awkward treatment of normal or tangential vectors and normal or tangential derivatives is not needed. In this talk, I will review the development of the $C\ell_3$-valued BEM and also examine its performance. The algebraic systems of $C\ell_3$-valued BEM for flat and curved elements will be obtained. Furthermore, corresponding BEMs will be applied to solve the problems of isotropic-linear elastic materials and the performance will be demonstrated.

Study on Variably Saturated Groundwater Flow Using a Spacetime Collocation Meshless Method

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National Taiwan Ocean University, Keelung 20224, Taiwan

Abstract

A pioneer study on numerical modeling of geofluid flow in variably saturated porous media using the spacetime collocation meshless method is presented. The numerical solutions are approximated by superpositioning basis functions satisfying the variably saturated flow equation for collocation points on the spacetime boundary. The spacetime collocation meshless method, which differs from conventional collocation methods based on a set of collocation points in space, is utilized in this study to assign boundary collocation points in the spacetime coordinate system. The initial and boundary conditions can be, therefore, treated as spacetime boundary conditions on the spacetime boundary. Numerical approximations are acquired by superpositioning the basis functions that automatically satisfy the variably saturated flow equation. The validity of the proposed approach is established for several validation problems, including the one-dimensional and two-dimensional variably saturated flow problems. The accuracy of the proposed approach is compared with that of a conventional time-marching scheme based on the finite difference method. Results obtained illustrate that highly accurate numerical approximations may be acquired. Furthermore, numerical errors may not accumulate over the entire time domain. Application examples of transient modeling of flow for rainfall-induced landslides in unsaturated porous media are also carried out. Numerical results demonstrate that the proposed approach is highly accurate to deal with transient flow in unsaturated porous media for rainfall-induced landslides. In addition, it is found that the proposed approach may provide promising solutions for different soil textures. Finally, the proposed approach is extended to solve the groundwater inverse problems.

Results show that the boundary data on the absent boundary may be recovered even when the partial data on the final time boundary are inaccessible. This pioneering study may provide a promising solution for the transient variably saturated flow problems. It is expected that the findings observed in this study may be a fundamental contribution to geoenvironmental engineering.

Keywords: Variably saturated flow, unsaturated porous media, numerical modeling, spacetime collocation meshless method, inverse problems.

BEM + MoM for Analysis of Plasmonic Modes

Jiunn-Woei Liaw[1,2], Yun-Cheng Ku[3], Mao-Kuen Kuo[3]

[1]Department of Mechanical Engineering, Chang Gung University, Taiwan
[2]Department of Mechanical Engineering, Ming Chi University of Technology, Taiwan
[3]Institute of Applied Mechanics, National Taiwan University, Taiwan

Abstract

In the past decay, several numerical methods have been developed to study the surface plasmon resonance of metallic nanoparticles (NPs), e.g. the finite difference time domain method, multiple multipole method [1], discrete dipole approximation, finite element method [2], and boundary element method (BEM) [3-5]. In this workshop, we present 3D surface integral equations (SIEs) of Fredholm's second kind in terms of surface unknowns (surface charges and surface currents) derived from Stratton-Chu formulation for Maxwell's equations. In these SIEs, the kernel functions are the difference of Green's functions of interior and exterior fields. We use the BEM combined with the method of moment (MoM) to numerically solve these SIEs. Based on this method, the distributions of surface charges and currents of plasmonic modes of a metallic NP excited by an incident light are studied. For example, the plasmonic modes of a silver nanotriangle excited by a normally incident circularly polarized light are analysed. In addition, the behaviour of the streamline of Poynting vector in the exterior field is also studied.

Keywords: BEM, MoM, surface integral equations, surface charge, surface current, Maxwell's equations, plasmonic modes

References:

[1] J.-W. Liaw, et al., "Light-driven self-organization of gold clusters by linearly polarized Gaussian beam", J. Quant. Spectrosc. Radiat. Transfer 233, 35−41, 2019.
[2] J.-W. Liaw, J.-C. Cheng, C. Ma, R. Zhang, "Theoretical analysis of plasmon modes of Au-Ag nanocages", J. Phys. Chem. C 117, 19586−19592, 2013.

[3] J.-W. Liaw, “Simulation of surface plasmon resonance of metallic nanoparticles by boundary-element method”, J. Opt. Soc. Am. A 23(1), 108−116, 2006.
[4] J. M. Taboada, et al., “Method-of-moments formulation for the analysis of plasmonic nano-optical antennas”, J. Opt. Soc. Am. A 28(7), 1341−1348, 2011.
[5] A. M. Kern, O. J. F. Martin, “Surface integral formulation for 3D simulations of plasmonic and high permittivity nanostructures”, J. Opt. Soc. Am. A 26(4), 732−740, 2009.

迷你論壇II

日期：10 月 17 日 13:30-15:30，地點：河工二館 404 室

講者	單位	講題
關百宸 副教授	國立臺灣海洋大學 系統工程暨造船學系	等參幾何法用於結構分析與聲場模擬計算
蔡加正 教授	國立高雄海洋科技大學 海洋環境工程系	Homotopy method of fundamental solutions for solving Poisson-type nonlinear PDEs and nonlinear heat conduction problems
黃宏財 教授	義守大學 財務與計算數學系	The Laplace Equation in Three Dimensions by the Method of Fundamental Solutions and the Method of Particular Solutions
呂宗澤 教授	國立中山大學 應用數學系	Characteristic Adomian Decomposition Method for Riemann Problem
李家瑋 助理教授	淡江大學 土木工程學系	Meshfree boundary integral equation method for solving two-dimensional interior Laplace and Helmholtz problems

等參幾何法用於結構分析與聲場模擬計算

林暐倫、陳兆杰、陳冠嘉、關百宸、魏祥丞

Systems Engineering & Naval Architecture (SENA), National Taiwan Ocean University, Keelung, Taiwan

摘要

本文主要探討與回顧目前等參幾何法在海洋工程相關領域的應用，主要分為兩個部分：一、結構共振與聲場共振計算；二、無網格法耦合與結構破壞模擬兩個方向。

等參幾何法是利用電腦輔助設計過程中所使用描述幾何的非均勻樣條函數(non-uniform rational B-spline function，NURBS)，同步用於描述模型的幾何形狀與近似物理場的形函數。NURBS 用於形函數有和為一與全正的特性，所以當用於動態問題時，沒有有限元素法高階單元的負質量問題，同時在處理特徵質問題時，因為幾何形狀是完全正確的，所以計算精確度高，再加上形函數兼具高階連續性，所以不會有一般有限元素法所遇到的特徵值計算不穩定的現象。本研究應用等參幾何法求解荷姆霍茲方程式，並引入特殊的消除型無窮邊界單元，模擬開放空間中的聲場行為，並驗證出本方法擁有優於一般網格類方法的準確度與可用性。

第二個應用主要的目標是使用等參幾何法分析船舶的結構破壞行為，由於等參幾何法非常適合描述三維空間的複雜曲板行為，但是不容易引入破裂時的不連續位移場，故本研究引入耦合最適合描述動態裂縫的近場動力學法來處理船殼裂縫擴張的問題。近場動力學法主要是一種顆粒類的無網格法，其特性是將連續力學的平衡方程式中的內力改寫成顆粒間的鍵結力，並可以用比較貼近連體力學的方式並且準確地描述裂縫成長的過程。本研究發展出連接顆粒類方法與等參幾何法的耦合計算技巧，並驗證耦合邊界上可以達到消除由於空間描述不一致導致的不穩定波後，將本方法用於曲面板的裂縫成長問題上，其計算效率比使用純近場動力學分析裂縫能節省大部分的計算時間，並且在船體建模上有著較高的效率與便利性。

Keywords: 等參幾何法、近場動力學、耦合、船體結構、聲場模擬

Homotopy method of fundamental solutions for solving Poisson-type nonlinear PDEs and nonlinear heat conduction problems

Chia-Cheng Tsai

Department of Marine Environmental Engineering, National Kaohsiung University of Science and Technology, Kaohsiung, Taiwan

Abstract

In this study, the homotopy analysis method (HAM) is combined with the method of fundamental solutions (MFS) and the augmented polyharmonic spline (APS) to solve Poisson-type nonlinear PDEs and nonlinear heat conduction problems. The method of fundamental solutions with high-order augmented polyharmonic spline (MFS–APS) is a very accurate meshless numerical method which is capable of solving Poisson's equation since the fundamental solution and the analytical particular solutions of the APS associated with the harmonic operator are known. In the solution procedure of the Poisson-type nonlinear PDEs, the HAM is applied to convert the considered nonlinear PDEs into a hierarchical system of linear Poisson's equations, which can be sequentially solved by the MFS-APS. On the other hand, in the solution procedure of nonlinear heat conduction problems, the Kirchhoff transformation is employed to transform the nonlinear governing partial differential equation into the Laplace equation with nonlinear boundary conditions. Sequentially, the HMFS is applied to solved the prescribed the Laplace equation with nonlinear boundary conditions. In order to solve strongly nonlinear problems, auxiliary parameters are introduced to ensure the convergence of the HAM. Therefore, the homotopy method of fundamental solutions can be applied to solve problems of strongly nonlinear PDEs. Several numerical experiments were carried out to validate the proposed method. Therefore, it can greatly enlarge the application areas of the MFS.

The Laplace Equation in Three Dimensions by the Method of Fundamental Solutions and the Method of Particular Solutions

Hung-Tsai Huang

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Abstract

For Laplace's equation in a bounded simply-connected domain Ω in 3D, the method of fundamental solutions (MFS) is studied in this paper. Although some numerical computations can be found in Chen et al. [1], the theoretical analysis is much behind (Li [2] only for unit sphere Ω). Our efforts are devoted to exploring a strict error analysis of the MFS. The error bounds are derived, and the optimal polynomial convergence rates can be achieved. Numerical experiments are carried out to support the analysis made, and several useful locations of source nodes are investigated numerically. The analysis in this paper may lay a theoretical basis of the MFS for 3D problems, as Bogomolny [3] and [4] for 2D problems. Besides, the method of particular solutions (MPS) in [5] is also studied by using the spherical harmonic functions (SHF). The optimal polynomial convergence rates and the exponential growth of condition number (Cond) are obtained. The source nodes are located based on the abscissas of quadrature rules on surfaces; they are "grid-like". Since most of 3D problems, in reality, can not be simplified to 2D problems, and since the MFS has more advantages for 3D problems in algorithm simplicity and wide application, the study in this paper is essential and important to the MFS.

Keywords: Method of fundamental solutions, Helmholtz equation, error analysis, stability analysis, condition number, degeneracy.

References:

[1] C.S. Chen, A. Karageorghis, Y. Li, On choosing the location of the sources in the MFS, Numer. Algor., 72, 107-130, 2016.
[2] X. Li, Convergence of the method of fundamental solutions for Poisson's equation on the unit sphere, Adv. Comput. Math., 28, 269-282, 2008.

[3] A. Bogomolny, Fundamental solutions method for elliptic boundary value problems, SIAM J. Numer. Anal., 22, 644-669, 1985.
[4] Z.C. Li, The method of fundamental solutions for annular shaped domains, J. Comput. Appl. Math., 228, 355-372, 2009.
[5] Z.C. Li, T.T. Lu, H.Y. Hu, A.H.-D. Cheng, Trefftz and Collocation Methods, MIT, Southampton, Boston, 2008.

Characteristic Adomian Decomposition Method for Riemann Problem

Chi-Kin Chau and Tzon-Tzer Lu
Department of Applied Mathematics, National Sun Yat-sen University, Kaohsiung, 80424, Taiwan

Abstract

The Adomian decomposition method (ADM) is a very powerful technique to solve nonlinear problems, including ordinary differential equations, partial differential equations (PDEs), differential-algebraic equations, differential-difference equations, integro-differential equations, stochastic systems and eigenvalue problems, etc. It is well known in literature that this method yields the rapidly convergent series solution and is a typical semi-analytic method with meshfree. For certain problems it even becomes an analytic method that captures the exact solution.

But ADM is not perfect. It is purely algebraic manipulation to compute solution without knowing geometry and physical meaning. We will show ADM has trouble to solve Riemann problems alone. Therefore the characteristic curve is chosen to assist ADM and overcome ADM's weakness. This combination is capable to deal with first order PDEs, linear and quasi-linear, with nonsmooth variables or piecewise initial/boundary conditions. Our numerical experiments show the proposed combined method for Riemann problems is far more accurate, reliable and efficient than existing traditional methods. Finally, this new method is compared in detail with the method of characteristics.

Keywords: Adomian decomposition method, semi-analytic method, meshfree, exact solution, first order partial differential equation, Riemann problem, piecewise data, method of characteristics.

Meshfree boundary integral equation method for solving two-dimensional interior Laplace and Helmholtz problems

Jia-Wei Lee, Yu-An Chuang and Shih-Chieh Teng

Department of Civil Engineering, Tamkang University, New Taipei City, Taiwan

Abstract

In this paper, a meshfree boundary integral equation method is proposed. Only boundary nodes are required for the present method different from the conventional boundary element method that needs to generate the mesh. For the problem of the Cauchy principal value, we introduce a local exact solution for a boundary point. By subtracting the boundary integral equation of original problem and boundary integral equation of local exact solution, the Cauchy principal value can be exactly evaluated. Free of calculating the solid angle for the boundary point is also gained. Therefore, the Gaussian quadrature is employed only once for the above boundary integral equation, the boundary integral equation is nothing but a algebraic equation. This is the reason why only boundary nodes are required in the present method. This idea can also preserve the flexibility of numerical method, hence it is suitable for any geometry shape. In a word, there are two advantages in the present method. One is mesh free. The other is free of calculating singular integral by using the sense of principal value. Finally, several examples such as a steady fluid flow in a rectangular domain, a seepage problem with a dam foundation, eigenproblems of annular and eccentric membranes, are considered to examine the validity of the present meshfree boundary integral equation method.

Keywords: meshfree boundary integral equation method, local exact solution, Gaussian quadrature, steady fluid flow, eigenproblems

會議場地位置平面圖


國立臺灣海洋大學
基隆主校區地圖
校區示意圖
育樂館
晚宴
河工二館
迷你論壇
工學院
大會演講
午餐
北寧路
中正路
1 行政大樓 F3
2 展示廳、海洋廳 F3
3 圖書館 G3
4 綜合研究中心 G4
5 綜合二館 G4
6 宏廣書屋 G3
7 郵局 F4
8 機械B館、電算中心 F3
10 育樂館 E2
12 延平技術大樓 E2
13 輪機實習工廠 E3
14 沛華大樓 E3
15 航管系館 D2
16 勇泉 D2
17 海空大樓 D2
18 游泳運動中心 D2
19 男三女二舍 D1
20 第二餐廳(勇泉商場) D1
21 男二舍 D1
22 學生活動中心 C3
23 體育館 D3
24 運動場 D4
25 籃球場 E4
26 海洋夢想基地 F4
27 小艇碼頭 F5
28 男一舍 G1
29 射箭場 F2
30 第一餐廳(夢泉商場) G2
31 綜合三館 G2
32 龍崗生態園區 G1
33 夢泉 G2
34 人文大樓 G2
35 山海迴廊 G3
36 女一舍 H2
37 海大農場 H2
38 海事大樓乙棟 G2
39 海事大樓甲棟 G3
40 創校紀念公園 G2
41 海事大樓丙棟 H2
42 校史博物館 H3
43 環態所館 H2
44 養殖溫室 H3
45 綜合一館 H2
46 海洋系館 H3
47 食安所館 H3
48 排球場、網球場 H3
49 漁學館 I2
50 生命科學院館 I3
51 食品工程館 H4
52 陸生動物實驗中心 H4
53 食品科學系館 H4
54 木蘭海洋海事教育大樓 I5
55 雨水公園 B2
56 海洋工程綜合實驗館 B3
57 壘球場 B4
58 河工一館 B3
59 沙灘排球場 B4
61 工學院、第三餐廳 C3
63 電機二館 C4
64 資工系館 C4
65 水生動物實驗中心 D4
66 海洋生物培育館 C4
67 聲學實驗中心 B4
68 電資暨綜合教學大樓 C4
70 河工二館 A2

基隆景點地圖

第十一屆台灣無網格法與邊界元素法學術研討會 製作

忘憂谷

「望幽谷」又名「忘憂谷」，意指站在高處俯瞰綠色山谷使人「忘」卻所有煩「憂」，是八斗子海濱公園觀景台下方綠油油的青翠谷地。

和平島公園

和平島位於台灣本島的最北端，為一處獨立的海島，後來興建和平橋與基隆市相連而成所謂的陸連島，有許多特殊的岩石景觀。

基隆港&海洋廣場

三面環山的基隆港是台灣最北端的港口，也是台灣的第二大港口，具備了軍事港口、貨運商港、客運碼頭與雜貨碼頭的多元功能性。

基隆廟口

「基隆廟口」小吃位於愛三路到愛四路間的仁三路兩側，基隆廟口小吃街的美食各有不同風味與歷史，更有許多具有台灣風味的零嘴小吃。

潮境公園

潮境公園潮境公園位於八斗子半島東側，臨望海巷海灣(或稱為換番大澳)，面積約一公頃。園區內設有規劃完善的枕木步道，還有許多藝術雕塑品。

正濱漁港

日據時期曾為台灣第一大港的正濱漁港就位在基隆和平島的南方，正濱漁港又稱為基隆漁港，是早期帶動基隆漁港興盛的主要功臣。

仙洞巖&佛手洞

位於基隆西北端的仙洞巖是一處特殊景觀的海蝕洞，相傳有仙人在此修行後得道昇天，因此稱為仙洞，洞前石梯旁佇立著一尊金色佛像供人膜拜。

情人湖公園

位在大武崙山上的情人湖公園，原本稱為五義埤，有基隆人的後花園之稱，由六條山澗集流而成的Y型高地湖泊。公園裡規劃了環湖步道、情人吊橋、觀景平台與風車等。

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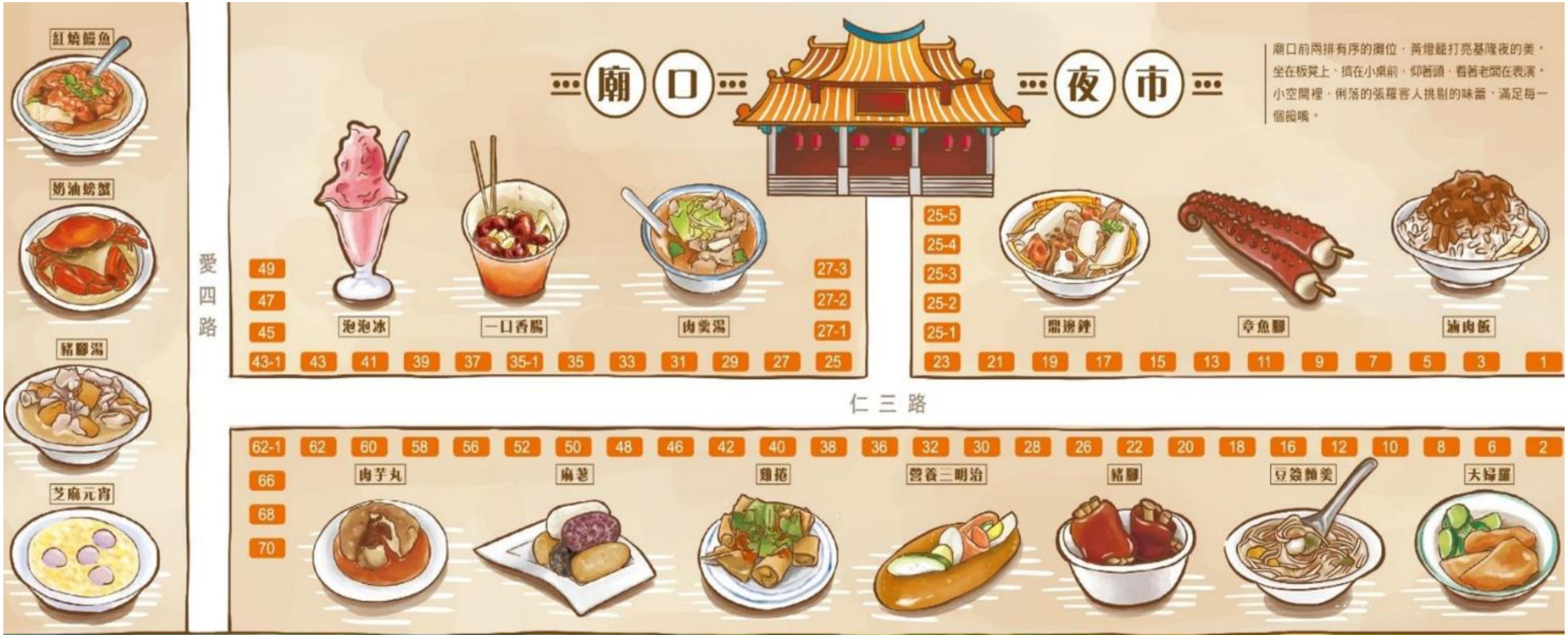
基隆著名美食&餐廳

基隆伴手禮推薦 top10

- 鳳梨酥－李鵠餅店
- 芋泥西米露－連珍糕餅店
- 芝麻核桃餅－珍味香餅鋪
- 傳統米香餅－江福記
- 頂級飛魚卵 XO 醬－心干寶貝
- 傳統小吃禮盒－基隆天婦羅
- 海鮮蘿蔔糕禮盒－食之飴
- 精釀啤酒組－大方合展
- 黑鳶飛翔餅乾－朋廚食品
- 海為夾心手工蛋捲禮盒－蔡技食品



1	鮮果汁大王	15	雞捲大王	25-3	何家排骨焿．手工捲．紅燒鰻	32	峰壽司日式料理	43-1	一口吃香腸	56	水果總匯
2	自製大腸圈	16	天婦羅	25-4	奶油螃蟹．蔥油蝦米粉湯	33	柳橙汁．牛奶	45	愛玉冰．冬瓜茶．蓮藕汁	58	營養三明治
3	酸梅湯．可可牛奶	17	炒咖哩麵	25-5	傳記天婦羅	35	香香塩酥雞	46	咖哩飯．鮮魚湯	60	什錦春捲
5	螃蟹焿/油飯	18	廣東麵	26	豆簽焿	35-1	手工大腸圈‧豬血湯	47	海鮮鍋燒麵．廣東粥	62	金興麻粩
6	米粉湯	19	光復肉焿	27	米粉湯	36	蚵仔煎	48	爆漿芋泥球．芋頭牛奶	62-1	金興麻粩
7	金針排骨．小菜	20	四神湯	27-1	羊肉焿．羊肉魯飯排骨麵	37	沈記泡泡冰	49	刈包．四神湯	66	油粿．芋粿
8	旗魚飯．鮮魚湯	21	魯排骨	27-2	吳家鼎邊趖	38	麵線焿．肉圓	50	林記刨冰總匯	68	章魚小丸子
9	三明治．咖啡可可	22	蝦仁焿	27-3	刑記鼎邊趖	39	謝記章魚腳	52	陳記壽司 / 生魚飯	70	蟹肉．蟹足．風螺
10	螃蟹焿/油飯	23	泡沫紅茶	28	油飯．肉焿	40	花枝焿．大麵炒				
11	魯肉飯．排骨湯	25	韓國魷魚焿	29	魯肉飯專家	41	陳記泡泡冰				
12	排骨麵	25-1	刑記鼎邊趖	30	林家素食．蝦仁焿	42	鹹粥．魷魚				
13	本港魚活海產	25-2	刑記鼎邊趖	31	魯肉飯．肉焿大王	43	一口吃天婦羅				

基隆廟口地圖

資訊來源:基隆旅遊網 https://tour.klcg.gov.tw/zh/

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第十一屆台灣無網格法與邊界元素法學術研討會

工作小組製作

國立臺灣海洋大學河海工程學系